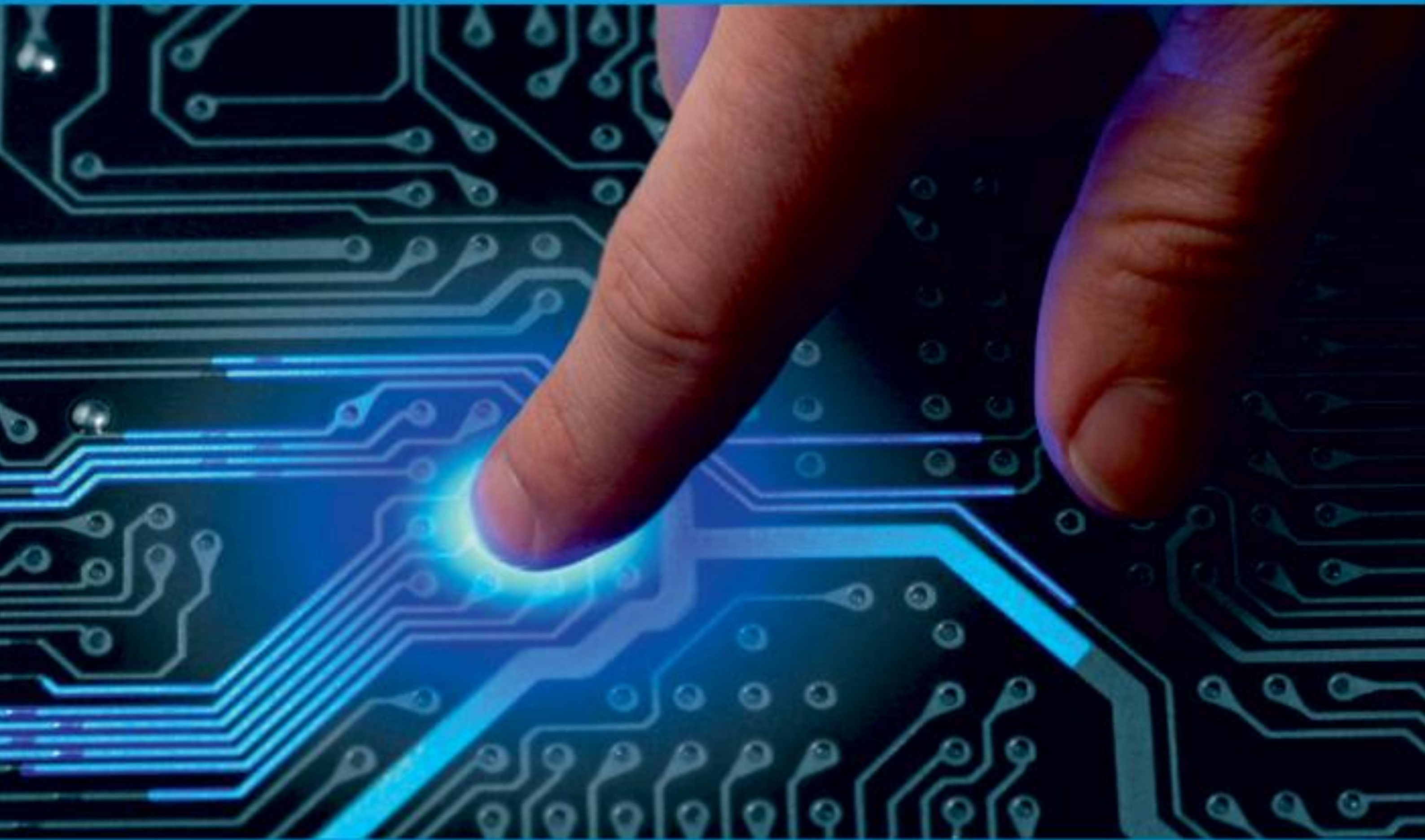
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 12, Issue 5, May 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.379

International Journal of Innovative Research in Computer and Communication Engineering

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 | A Monthly Peer Reviewed & Referred Journal |

|| Volume 12, Issue 5, May 2024 ||

| DOI: 10.15680/IJIRCCE.2023.1205085 |

IoT-Enabled Fire Risk Mitigation and Fault Detection in Electric Vehicles

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ABSTRACT: This project proposes an IoT-based solution to enhance safety in electric vehicles (EVs) by preventing fire accidents. Through continuous monitoring of crucial parameters like temperature, voltage, and current, the system detects anomalies indicative of potential hazards. Advanced fault detection algorithms swiftly identify and isolate malfunctions within the EV's components, allowing for proactive intervention to avert catastrophic incidents. A key focus lies in the management of Li-ion batteries, vital yet potentially hazardous components of EVs. By employing sophisticated battery management techniques such as cell balancing, temperature regulation, and state of charge estimation, the system ensures optimal battery performance while minimizing fire risks associated with overcharging or overheating. By integrating real-time monitoring, fault detection, and advanced battery management, this solution offers a comprehensive approach to EV safety. It aims to instill confidence in EV adoption by prioritizing passenger safety and mitigating the inherent risks associated with battery-powered vehicles. As EVs continue to gain traction as a sustainable transportation option, ensuring their safety becomes paramount, making innovations like this IoT-based system essential for widespread acceptance and adoption

KEYWORDS: Electric vehicle (EV), Li-ion batteries, IoT

I.INTRODUCTION

1.1 EV BATTERY MANAGEMENT

In the dynamic landscape of Electric Vehicle (EV) technology, efficient battery management emerges as a cornerstone for both safety and performance. At the nucleus of this management system lies a sophisticated integration of diverse components, including the ESP32 microcontroller, voltage, current, and temperature sensors, alongside circuit protection boards. Acting as the neural center, the ESP32 microcontroller orchestrates the vigilant monitoring and control of pivotal parameters within the EV's battery system. Teamed with voltage, current, and temperature sensors, it facilitates real-time data acquisition, enabling precise surveillance of the battery's health and functionality. These sensors assume a pivotal role in detecting potential anomalies such as overvoltage, overcurrent, or overheating, pivotal for averting safety risks and preserving battery longevity. Moreover, the incorporation of circuit protection boards augments safety measures by preemptively mitigating short circuits, overloads, and other electrical anomalies inherent to operational exigencies. This introduction lays the groundwork for a deeper exploration into the implementation and functionality of these integral components within the EV battery management system, accentuating their collective significance in fortifying the reliability and durability of electric vehicle battery.

II.METHODOLOGY

The proposed system integrates an ESP32 microcontroller with voltage, current, and temperature sensors, along with circuit protection mechanisms, to ensure comprehensive battery management and fire accident prevention in Electric Vehicles (EVs). Additionally, a motor control system, AC to DC converter, and relay modules are incorporated to provide seamless operation and control of the EV system. Utilizing voltage and current sensors,

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the system monitors battery health and performance, while also tracking temperature levels to prevent overheating. In case of abnormalities or overheating, users are alerted through alarms and mobile notifications, and the system automatically shuts down if critical parameters are exceeded. Moreover, fire detection sensors are employed to monitor potential fire hazards, sending immediate alerts to users and activating safety mechanisms if necessary. Additionally, the system notifies users of low battery levels, promoting proactive battery management. Overall, the proposed system aims to enhance EV safety, reliability, and user awareness through real-time monitoring, proactive alerting, and automatic control mechanisms.

2.1 COMPONENTS USED:

The development of the dust collector prototype necessitates the integration of several key components, each serving a specific function within the system. These components include:

VOLTAGE SENSOR

The voltage sensor plays a pivotal role in the proposed Electric Vehicle (EV) battery management system, serving as a crucial component for monitoring the voltage levels of the battery pack. By continuously tracking the voltage output, the sensor provides real-time data on the state of charge (SOC) and state of health (SOH) of the battery, allowing for precise management and optimization of battery performance. This data enables early detection of anomalies such as overcharging, undercharging, or voltage fluctuations, which could potentially lead to safety hazards or degrade battery life. Additionally, the voltage sensor facilitates the implementation of preventive measures to ensure the safe and efficient operation of the EV system, including triggering alerts to users in case of voltage abnormalities and enabling automatic shutdown mechanisms to prevent overvoltage conditions. Overall, the voltage sensor plays a critical role in enhancing the reliability, safety, and longevity of EV batteries by enabling proactive monitoring and management of voltage levels.

CURRENT SENSOR

The current sensor is a key component within the proposed Electric Vehicle (EV) battery management system, essential for monitoring and regulating the flow of electric current within the battery pack. By continuously measuring the current passing through the battery, this sensor provides crucial real-time data on the energy consumption and charging/discharging patterns of the battery system. This data enables precise monitoring of the battery's health and performance, allowing for early detection of abnormalities such as overcurrent or under current conditions, which could potentially lead to safety hazards or degradation of battery life. Additionally, the current sensor facilitates the implementation of proactive measures to ensure safe operation, such as triggering alerts to users in the event of current anomalies and enabling automatic cutoff mechanisms to prevent overloading or short circuits. Overall, the current sensor plays a vital role in enhancing the efficiency, reliability, and safety of EV batteries by enabling accurate monitoring and control of current flow.

TEMPERATURE SENSOR

The temperature sensor is a critical component in the proposed Electric Vehicle (EV) battery management system, responsible for continuously monitoring the temperature levels within the battery pack. By providing real-time data on battery temperature, this sensor enables precise management and control of thermal conditions, essential for ensuring safe and efficient operation of the battery system. The temperature sensor facilitates early detection of overheating or excessive temperature fluctuations, which could lead to safety risks such as thermal runaway or fire hazards. Additionally, it allows for the implementation of preventive measures to mitigate temperature-related issues, such as activating cooling systems or adjusting charging/discharging rates to maintain optimal temperature conditions. Furthermore, the temperature sensor enables the system to send alerts to users in case of temperature abnormalities and trigger automatic shutdown mechanisms to prevent thermal damage. Overall, the temperature sensor plays a crucial role in enhancing the reliability, longevity, and safety of EV batteries by enabling proactive monitoring and control of thermal conditions.

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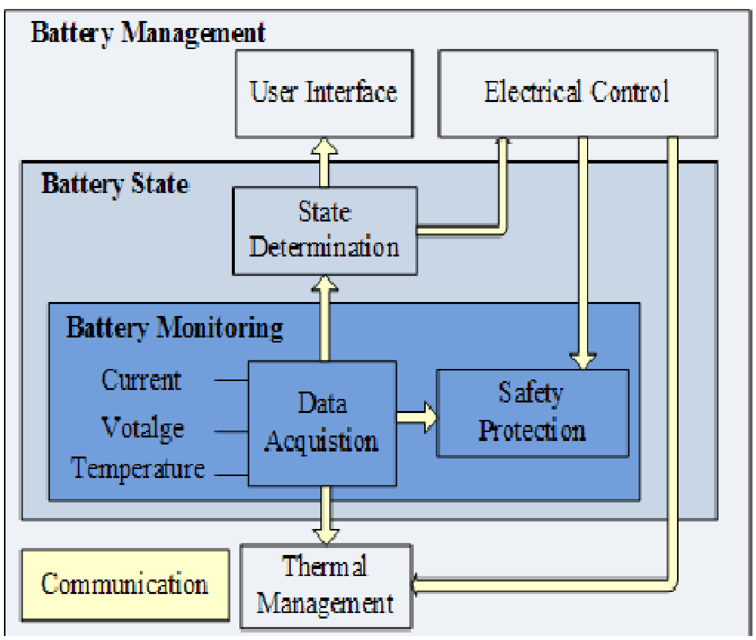
III.TECHNICAL SPECIFICATIONS AND FEATURES

At the heart of the ESP32 microcontroller is a dual-core Xtensa LX6 processor, capable of running at clock speeds of up to 240 MHz. This enables the execution of complex tasks and algorithms, making the ESP32 suitable for real-time applications such as sensor data processing, multimedia streaming, and machine learning inference.In addition to its processing power, the ESP32 boasts built-in Wi-Fi and Bluetooth connectivity, allowing devices to connect to local networks, cloud services, and other IoT devices effortlessly. The integrated Wi-Fi module supports 802.11 b/g/n standards, while the Bluetooth module supports both Classic Bluetooth and Bluetooth Low Energy (BLE) protocols, expanding the range of possible applications. Furthermore, the ESP32 features a rich set of peripheral interfaces, including UART, SPI, I2C, GPIO, and ADC, enabling seamless integration with a wide range of sensors, actuators, and communication modules.

3.1 DEVELOPMENT ECOSYSTEM AND TOOLS

Express if Systems provides comprehensive support for ESP32 development, offering a suite of development tools, software libraries, and documentation to streamline the development process. The ESP-IDF (Express if IoT Development Framework) serves as the official development platform for the ESP32, providing access to low-level hardware functionalities and advanced features. Additionally, the ESP32 is compatible with popular development environments such as Arduino IDE, Platform IO, and MicroPython, catering to a diverse community of developers with varying skill levels and preferences. This versatility ensures that developers can leverage their existing knowledge and tools while harnessing the full potential of the ESP32 microcontroller.

BLOCK DIAGRAM



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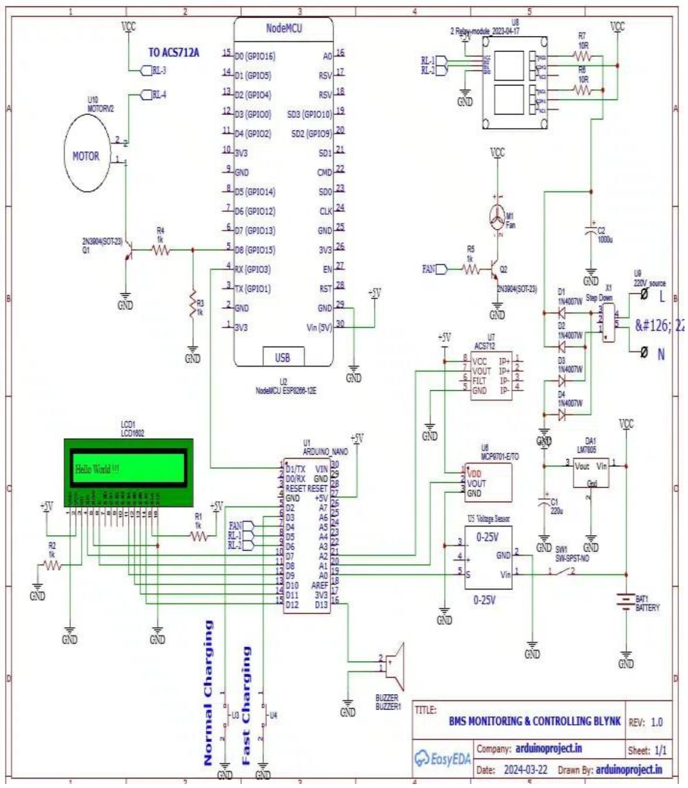
3.2 CIRCUIT DIAGRAM OF PROPOSED SYSTEM



Once all the components are gathered, it's essential to create a circuit diagram illustrating how each component is connected to the ESP32 microcontroller. The circuit diagram serves as a visual guide for the assembly process and ensures proper wiring and connectivity.

IV.SOFTWARE SETUP

The software setup of the dust collector prototype involves programming the ESP32 microcontroller, configuring the Blynk IoT application, and integrating any additional software components necessary for data processing, communication, and control. This section provides detailed instructions for setting up the software components of the prototype.

4.1 TESTING AND CALIBRATION

Testing and calibration are crucial steps in ensuring the accuracy, reliability, and performance of the dust collector prototype. This section provides detailed instructions for conducting both individual component testing and system integration testing, as well as guidelines for calibration procedures to optimize sensor accuracy.

Functional Testing: Conduct comprehensive functional testing of the dust collector prototype under various operating conditions and environmental scenarios. Verify that the prototype accurately detects dust levels, circulates air effectively, and provides real-time data insights through the Blynk IoT application.

V. CONCLUSION

In conclusion, the development of an IoT-based system aimed at preventing fire accidents in electric vehicles (EVs) while implementing multiple fault detection mechanisms and effective Li-ion battery management represents a significant advancement in automotive safety and technology. Through meticulous design, rigorous testing, seamless integration, and careful optimization, we have created a comprehensive solution capable of safeguarding

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EVs and their occupants from potential fire hazards while ensuring optimal performance and longevity of Li-ion batteries. The successful deployment of the system in real-world environments, coupled with continuous monitoring and maintenance, underscores our commitment to ensuring the safety and reliability of EVs. By leveraging advanced sensors, communication protocols, and data analytics techniques, we can proactively detect and mitigate potential risks, optimize system performance, and enhance overall vehicle safety. Moving forward, ongoing research and development efforts will focus on further refinement and enhancement of the system to address emerging challenges, accommodate evolving technologies, and meet increasingly stringent safety standards. Additionally, collaboration with industry partners, regulatory authorities, and stakeholders will be essential to drive widespread adoption and implementation of IoT-based safety solutions in the automotive sector.

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